Document title:

H1.2D INSTALLATION AND OPERATION

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INTRODUCTION

During my internship at Jan de Nul I worked at two different projects. One project was in Kaohsiung, where I worked most time of my internship. When my internship started the project was already halfway and I worked there until the end of the project. The second project was in Mailiao, this was a small project and I worked there from the beginning. During my time in Kaohsiung I already learned a bit about the base station, but of course I wasn't there during the set-up of the base station. In Mailiao I had to set up the base station.

For the Standard of Competence reports we had to choose three different subjects. Two subjects needed to be from the document with all the SOC subjects and one subject you could choose yourself. The subject for this report I chose myself? I chose this subject because the base station is one of the most important setups you need before you can do a survey. During my time as a trainee I will have to check the base station regularly and I also have to demobilize and mobilize a base station. I think that at the end of my internship I will have enough information and results to put in this report.

In this report I will first tell about the set-up of the base station in Mailiao, then about the problems we had with the base station in Kaohsiung and at last I will talk about errors that influence the accuracy of a base station.

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1 SETTING UP A BASE STATION

When the project in Kaohsiung was finished we moved all the equipment with us to the new project in Mailiao. Here we had to set up a base station. Jan de Nul did this project for the 5th time, so the position of the base station was already known. The position of the base station was on top of building in the harbour of Mailiao. It was placed close to the tidal gauge.
It was placed on top of a building so there was no disturbance of other buildings or objects and on that place the signal could reach over the whole harbour.

In the picture below is shown were the base station was placed in reference with the rest of the harbour.

Image 1 Base station location harbour Mailiao

1.1 THE BASE STATION EQUIPMENT

We used exactly the same equipment as the equipment used at the project in Kaohsiung. After we demobilized the base station in Kaohsiung we packed it in boxes and took it with us to Mailiao.
The devices we used for the base station are explained below.

1 UHF antenna + Trimble GNSS
The Trimble GNSS receives information from the satellites. The UHF antenna transmits the information it gets from the ADL, which is explained below.

Image 2 UHF antenna + Trimble GNSS

C-nav 3050

The C-nav 3050 is a GPS receiver. It can be used as a rover or base. In this case the CNAV3050 is used as base. This means it will receive threw the connected GPS antenna (Trimble GNSS) information from several satellites (GLONAS, GPS, Galileo). With this information the unit can calculate a current position of the connected GPS antenna. As the unit is used as base the exact position is known and it will compare the known position to the calculated position. The difference between the known position and calculated position is outputted as a serial string from the unit to the ADL.

ADL
An ADL is a radio modem that can transmits a serial string (text data) over a range of radio frequencies. The ADL is connected to the C-nav and UHF antenna. The ADL receives the outputted serial string from the C-nav and transmits this in a way it can be received by the antennas on board of the survey vessel and the Charles Darwin.

UPS (uninterruptable power supply)
An UPS is a battery, which makes sure the base station will never stop working. The battery is connected to a power source so the battery will not run out of charge. When the power source stops working the base station will still work because the battery has saved power.

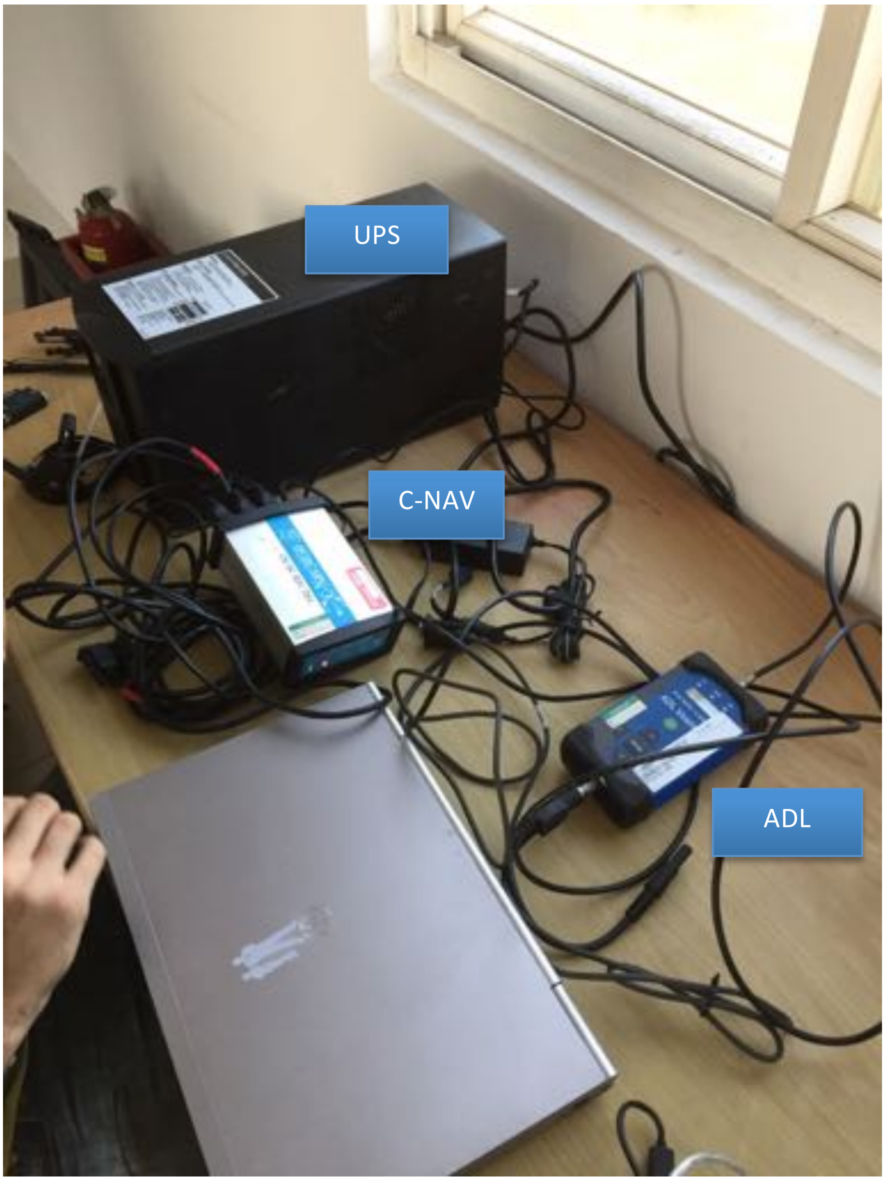


Image 3 Equipment base station

1.2 SETTINGS

During the installation of the base station you need to fill in the coordinates of the base station. This is the 5th time the project needed to be done and the base station was placed at the same position as previous times. The coordinates used previous years should not have changed so we filled in the coordinates used last year. In the picture below the position we filled in is shown.

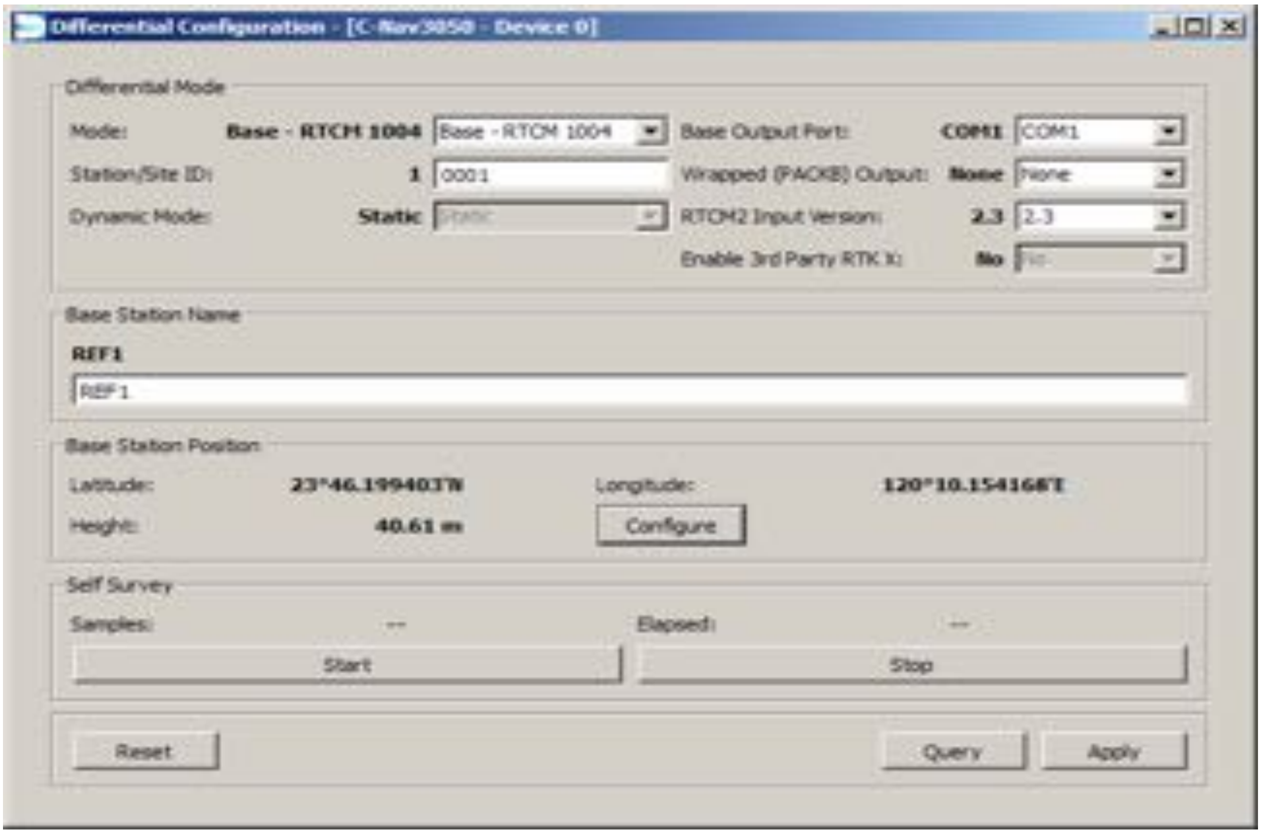


Image 3 Settings base station

After filling in the coordinates an internal Renix logging was started. The next day we came back and uploaded the loggings of the time it was on. You can send the logged data from the base station to a company or government organization that will calculate the exact position of the base station. We send the logging to AUSPOS. AUSPOS Online GPS Processing Service uses International GNSS Service (IGS) products to compute precise coordinates in ITRF anywhere on Earth and GDA94 within Australia.

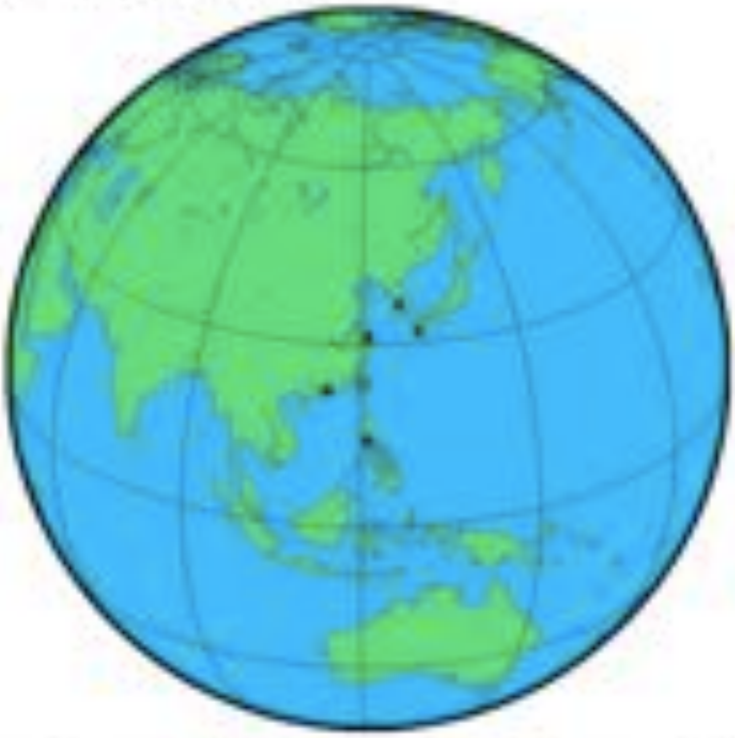
24 hours after the logging is done you can send it to AUSPOS. This is because all the satellites used need to go past the location again. The company uses the information it gets from all those satellites to calculate the position of the base station. On the next page you see the report AUSPOS send us.

1 User Data

All antenna heights refer to the vertical distance from the Ground Mark to the Antenna Reference Point (ARP).

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

2 Processing Summary



[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Remark: An IGS Rapid Orbit product has been used in this computation. IGS Rapid orbits are usually of very high quality. However, to ensure you achieve the highest quality coordinates please resubmit approximately 2 weeks after the observation session end to ensure the use of the IGS Final Orbit product.

AUSPOS 2.3 Job Number: # [illegible]
User: [illegible]

2

3 Computed Coordinates, ITRF2008

3.1 Cartesian, ITRF2008

Station	X (m)	Y (m)	Z (m)	ITRF2008 @
[illegible]	-2995279.419	[illegible]	[illegible]	14/11/2016
[illegible]	-3030185.797	4118797.234	[illegible]	14/11/2016
[illegible]	-3120042.320	4084614.726	3764026.810	14/11/2016
[illegible]	-2393382.960	[illegible]	2412082.267	14/11/2016
[illegible]	-2430579.047	5374280.468	2418808.126	14/11/2016
[illegible]	-3190293.611	5269024.393	1601158.369	14/11/2016
[illegible]	-2831733.061	4675665.798	3275369.285	14/11/2016

3.2 Geodetic, GRS80 Ellipsoid, ITRF2008

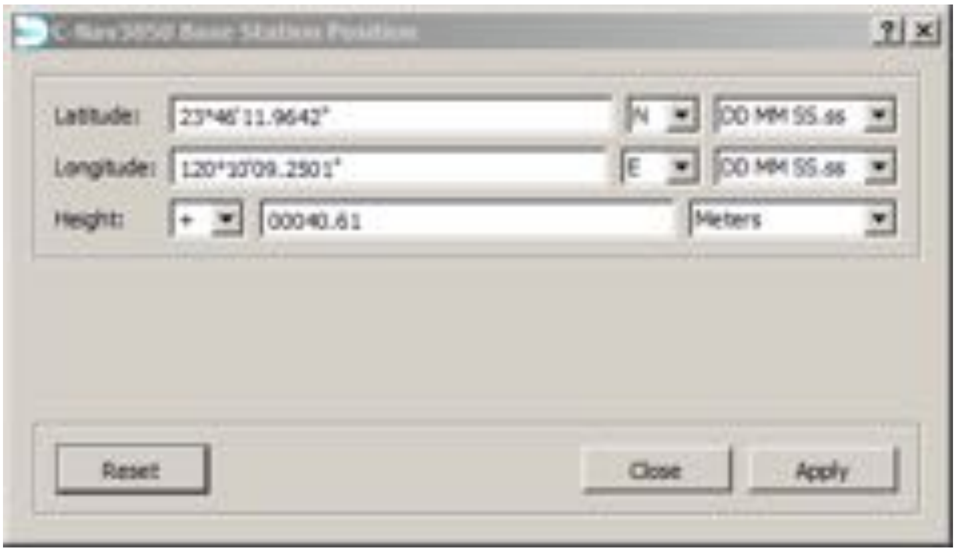
Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
[illegible]	23 44 11.96424	120 10 09.26206	42.613	21.842
[illegible]	31 49 28.61441	130 35 18.64682	218.659	202.794
[illegible]	36 22 57.93912	127 22 28.12682	116.666	91.831
[illegible]	22 22 18.21278	113 55 42.75329	95.251	98.794
[illegible]	22 26 03.40999	114 20 07.37984	63.741	65.626
[illegible]	14 39 08.18082	121 04 39.82271	95.538	51.422
[illegible]	31 05 58.70829	121 12 01.41380	22.692	11.339

3.3 Positional Uncertainty (95% C.L.) - Geodetic, ITRF2008

Image 5-6 Report AUSPOS

In this report the Cartesian and Geodetic coordinates given. The positional uncertainty of the longitude, latitude and height are also given in this report.

After receiving this report we went back to the base station and filled in the new coordinates. We used the geodetic coordinates.



<u>Image 7 Settings base station</u>

The base station sends the difference between these coordinates and the coordinates received by the satellites. The difference between these coordinates is called the RTK correction. The survey vessel and the Charles Darwin receive these RTK corrections.

2 BASE STATION IN KAOHSIUNG

In Kaohsiung the harbour and a little part outside the harbour had to be dredged. To get a position in the whole harbour was quite difficult. In length the harbour was about 11 km long. First they only installed a Base Station in the middle of the area. They had to start dredging in the area just outside the harbour, they noticed in that area was no RTK correction received. It was decided to install the Base Station at a new location. On the position of the first base station a repeater was installed.

2.1 FIRST BASE STATION

The first base station was installed on top of a dock close to the tidal metre.
They started dredging in area G, which is outside the harbour (on the picture it's the area at the left side). The signal of the base station couldn't reach to area G. At the port mouth there were two mountains and the signal couldn't reach over the mountains. That's why in that area they couldn't get a RTK fix. Since the base station and after that the repeater was placed on a dock, the steel can cause multipath errors. What multipath errors are will be explained in the following chapter.
In the pictures below you can see where the base station was installed first and how it looked.

Image 8 Harbour of Kaohsiung

2.2 SECOND BASE STATION AND REPEATER

Because they couldn't get the position signal to reach to area G, they installed the base station at a different place. They installed it closer to the end of the harbour and at a place so it could reach through the two mountains. The base station was place on top of a hotel. The left yellow pin is the place of the new position of the base station. Now the base station could reach area G, but the signal couldn't reach all the way to the other side of the harbour.

That's why they installed a repeater. The repeater was placed at the position where first the base station was placed. In the picture this is the right yellow pin.

Image 9 Harbour Kaohsiung dredging area

Image 10-11 Base station

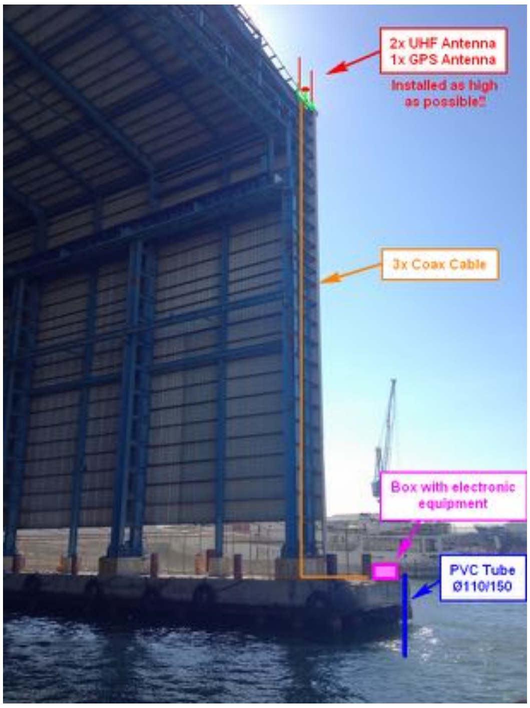


Image 12-13 Repeater

A repeater consists out of two UHF antennas, one that receives and transmits the tide and one that receives and transmits the RTK corrections. In the picture on the next page you will also see there was placed a GPS antenna. The GPS antenna had no use after it became the repeater instead of the base station.

3 ERRORS

Errors in the received GPS signal can result from various sources. There can be one error source or a combination of two or more. These errors result in a reduction in the accuracy obtained. The major error sources are listed below.

Multipath errors

Multipath is a phenomenon in the physics of waves where a wave from the source (satellite) travels to a receiver (antenna) via two or more paths. The multipath signals, reflection delayed signals, not only confuse the receivers' calculations but it also can cause a wave interference with the direct signal. This will result in a confused or noisy result. This can be caused by high buildings, mountains, steel and other objects. Multipath signals should be rejected by the receiver, if not it may result in an inaccuracy of the calculated position.

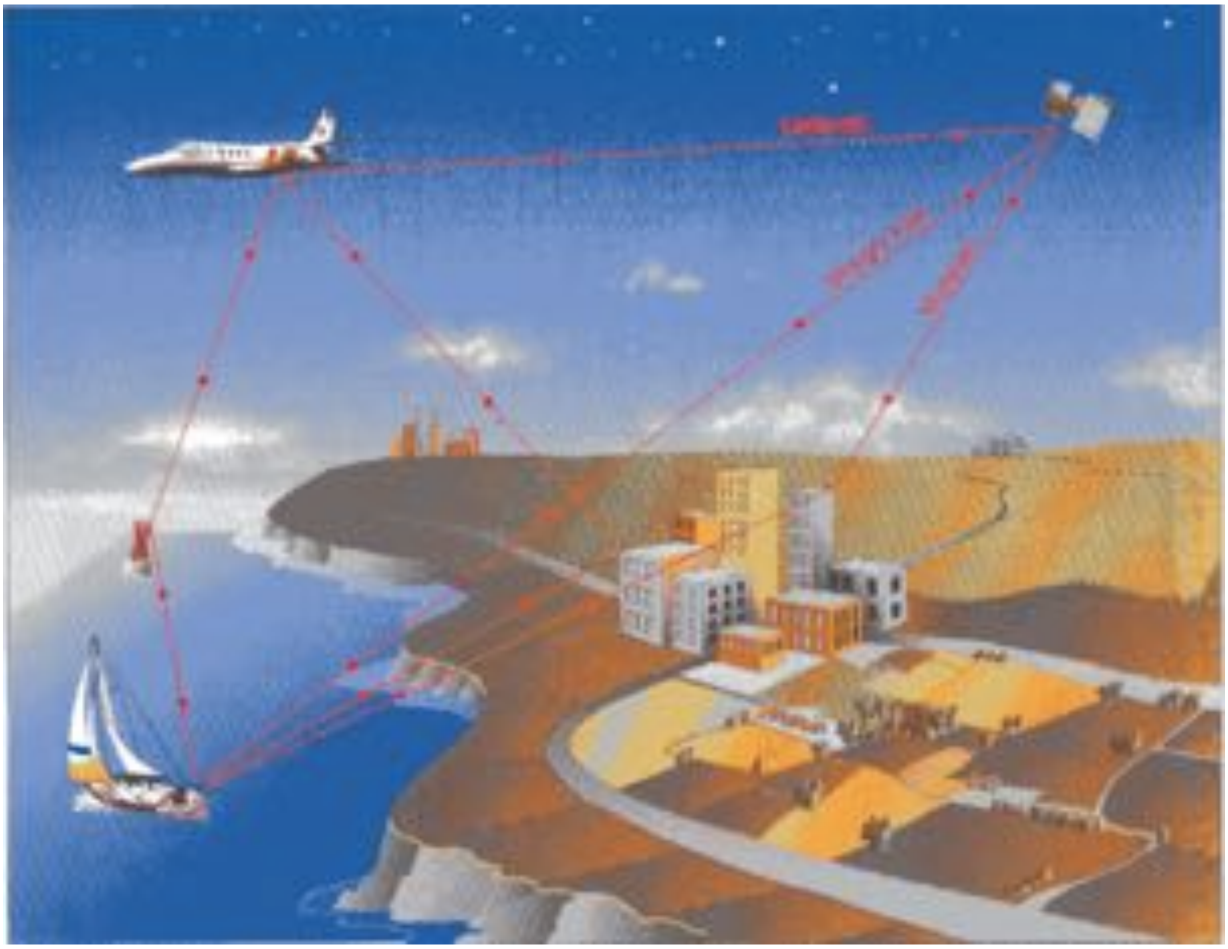


Image 14 Multipath

Atmospheric and Ionospheric errors

These errors can be caused when the signal from the satellite passes through the ionosphere and troposphere.

The ionosphere is characterised by high ion density and starts at 70-80 km above the Earth's surface. The troposphere is characterised by containing the greatest mass of air and almost all of the water vapour. The troposphere is in the lower part of the atmosphere, at the poles it stretches form the ground level to 9 km and at the equator to 16 km.

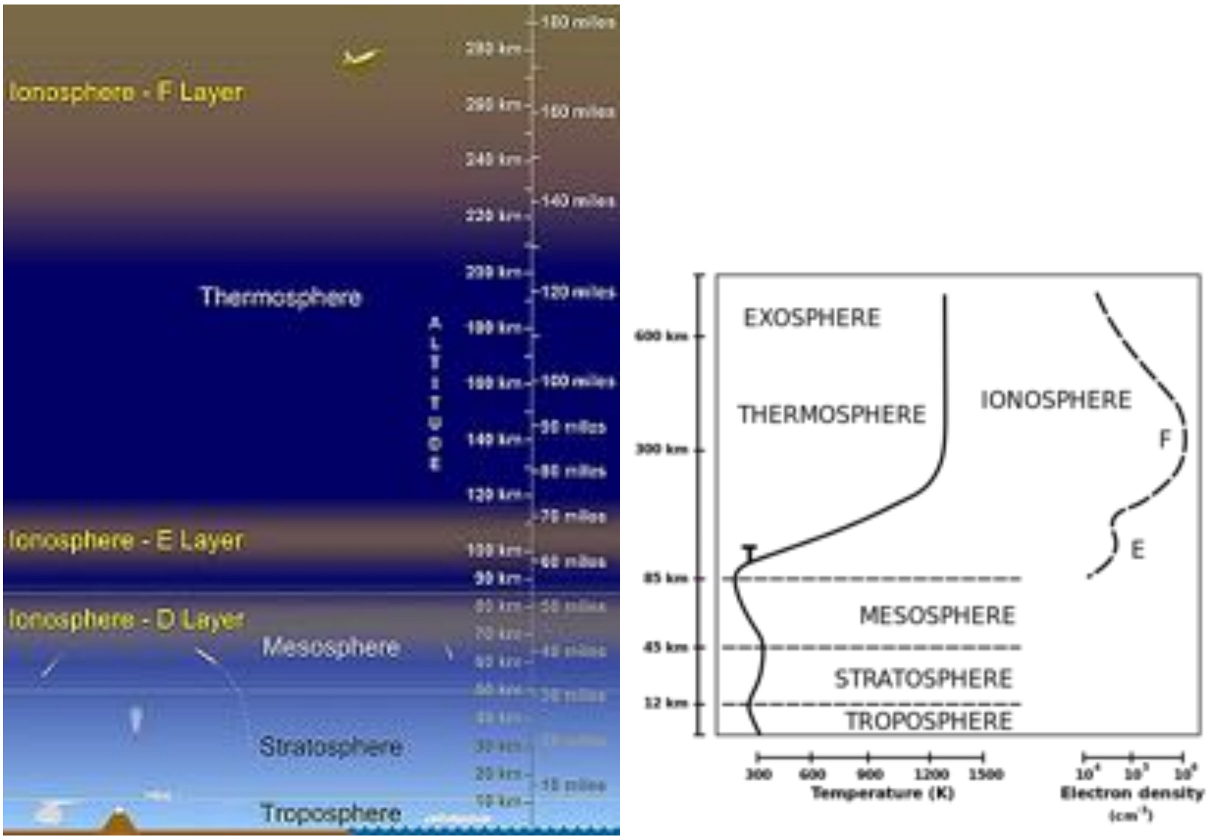


Image 15 -16 Atmosphere

The ionosphere includes the thermosphere and parts of the mesosphere and exosphere. It is ionized by solar radiation and plays an important part in atmospheric electricity. It forms the inner edge of the magnetosphere. It is an important part of the atmosphere because it influences radio propagation to distant places on Earth.

Because of the high ion density in the ionosphere the satellite signals will get delayed in this area of the atmosphere. In the ionosphere atomic oxygen and nitrogen predominate under very low pressure. The chance of refraction in the ionosphere increases with the density of free-moving electrons. So when there a more electrons moving in the ionosphere the electromagnetic waves will have a greater change at refracting.

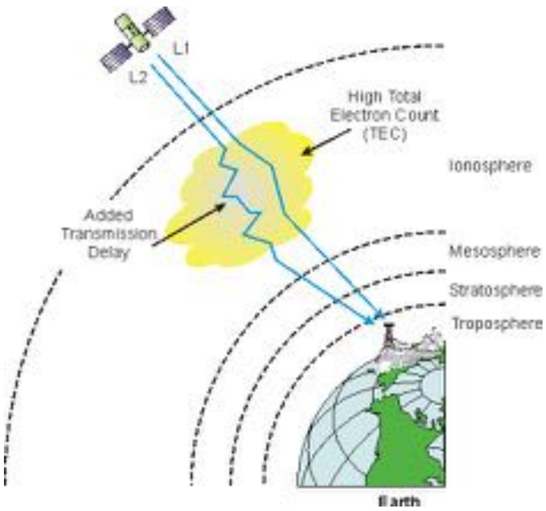


Image 17 Ionosphere

The troposphere experiences complex and volatile changes in pressure, temperature, density and humidity due to the interaction of weather systems. All these things can also cause the satellite signal to get delayed.

In the troposphere there can appear atmospheric ducts. An atmospheric duct is a horizontal layer in the atmosphere. The duct limits the spread of a signal to only the horizontal dimension. These ducts will usually occur in the lower layers of the earth's atmosphere. Here the waves will be bent by atmospheric refraction.
The picture below shows how an atmospheric duct works. The signals will be trapped in the atmospheric duct.

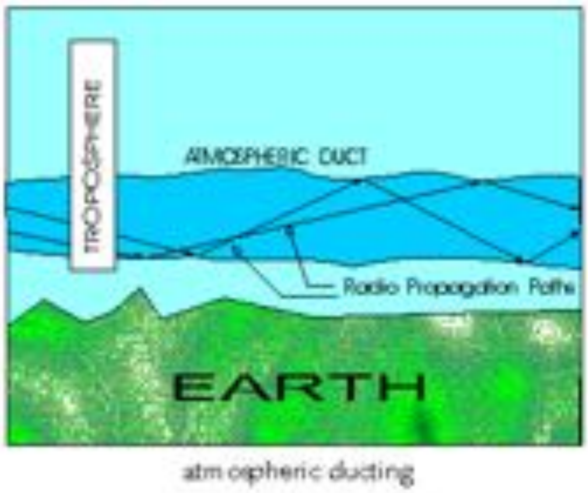


Image 18 Atmospheric ducting

Satellite Clock Bias errors

The atomic clocks within the satellite have minute discrepancies in accuracy. Although the atomic clocks are very accurate these very small discrepancies can result directly into signal travel time measurement errors. Clock errors can degrade the calculated position by 1-5 metres.

Positional errors

The exact position of every orbiting satellite within a positioning system is constantly being monitored but very small positional errors do take place. These minute errors can occur between the specific monitoring periods and may result in small inaccuracies within the calculated position leading to errors in the order of approximately 2-5 metres.

Geometric Dilution of Precision (GDOP)

The GDOP is the effect on position error by the distribution of the satellites being tracked by a GPS receiver. Wider spread satellites will result in a smaller position error, but if the elevation of these satellites is low they will produce poor vertical position, which can affect the determination of the latitude.

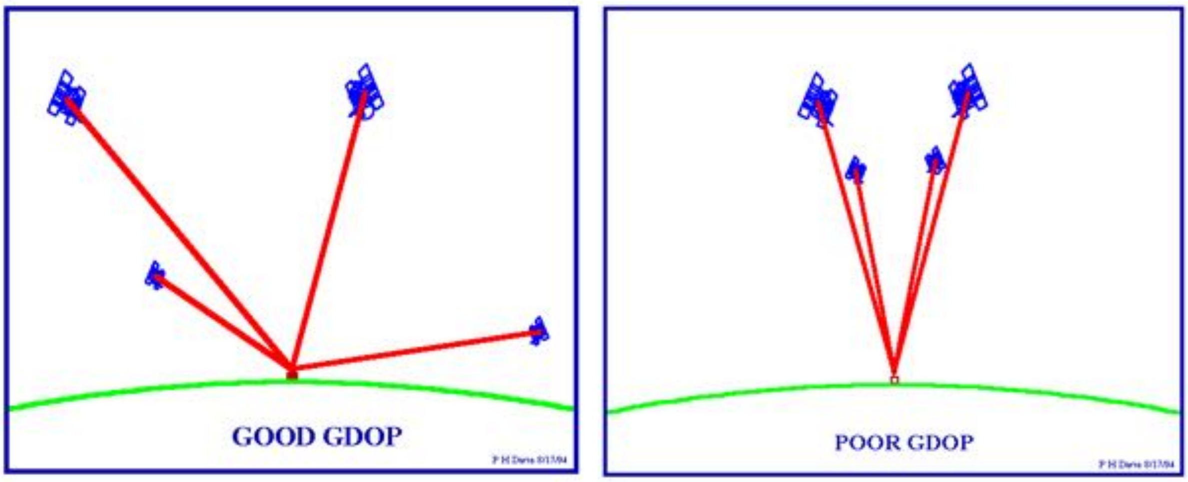


Image 19-20 Good/bad GDOP

Good quality receivers have the ability to determine which combination of satellites gives the best possible calculated result.

The receiver we used at the projects in Taiwan had this ability.

4 EPILOGUE

During my internship at Jan de Nul I found this subject one of the hardest to understand. A base station has different receivers and transmitters and just in general quite a lot of devices. I did find this subject very interesting, especially how the atmosphere works and how it can influence the accuracy of a base station. A base station is a very important structure to have at a project, because without one you do not have an accurate position

I think with making this report I learned a lot and I do not find the subject that hard anymore.

5 SOURCES

https://en.wikipedia.org/wiki/Multipath_propagation
https://en.wikipedia.org/wiki/Radio_propagation
https://en.wikipedia.org/wiki/Atmospheric_duct
https://en.wikipedia.org/wiki/Ionospheric_reflection
https://en.wikipedia.org/wiki/Refraction
https://en.wikipedia.org/wiki/Reflection_(physics)
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https://en.wikipedia.org/wiki/Error_analysis_for_the_Global_Positioning_System#Multipath_effects
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https://elo.nhl.nl/bbcswebdav/pid-413547-dt-content-rid-980919_1/courses/TECH_MI_05_1067/Course%20Documents/Equipment%20Global%20Positioning%20System%20Satellite%20Navigation/GPS_fmALRS.pdf
http://scied.ucar.edu/ionosphere
Surveywiki – Jan de Nul
Simon Steels – Surveyor at site
http://www.sssi.org.au/userfiles/docs/Hydrography/documents_1475536020108487758 8.pdf